

TUBULAR FABRIC AND METHOD OF MAKING THE SAME

The present invention relates to a tubular fabric, a method of making the same and to articles manufactured therefrom, particularly underwired
5 garments such as brassieres.

It is known to produce fabric tubing for receiving a curved underwire. Conventionally such fabric tubing is made by forming three separate fabric strips. The strips are folded and sewn together to form a tube into which an
10 underwire can be received.

A considerable problem with known fabric tubing for underwires is that the ends of the underwires can penetrate the tubing, either during the course of garment manufacture or in use by a wearer.
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At present, a significant proportion of brassiere (bra) manufacturers products are returned because of protrusion of the underwire through the fabric tubing.

Underwire protrusion through the tubing is perhaps most commonly the
20 result of washing the garment such as a bra in a washing machine. Whilst such washing is not presently recommended by garment manufacturers, it is commonplace. Clearly, product failure as a result of underwire protrusion is costly and can have a deleterious effect on customer satisfaction.

25 These problems were addressed in GB 2,309,038, which provided a tubular fabric for receiving an underwire, the fabric comprising a support yarn, an elastomeric yarn and a fusible yarn which was arranged within the fabric tube so that it was capable of forming a penetration barrier.

It was known that the elastomeric yarn was required to lend the fabric a desirable degree of flexibility or "give" which is important, as the fabric must be curved to receive an underwire. GB 2,309,035 noted that if the fabric did not include the elastomeric yarn it would not lie flat and be puckered when the underwire was in position, making the finished product unappealing aesthetically and uncomfortable to wear. GB 2,309,038 noted that a skilled person would appreciate that a range of elastomeric yarns could be employed, and that an elastane e.g. Lycra® is preferred both for its well proven performance and widespread commercial acceptance. A particularly preferred Lycra® yarn in GB 2,309,038 is distributed by Wykes of Leicester, England under their product code 2581 and comprises a core of 235 decitex (dtex) Lycra® (Du Pont) covered on top by 1 fold 78 dtex textured 18 filament Nylon 6 (Du Pont) and on the bottom by 1 fold 78 dtex textured 18 filament Nylon 6 (Du Pont).

15 In light of GB 2,309,038, it has been surprisingly shown that a fabric tube capable of preventing underwire protrusion can be formed without using an elastomeric yarn.

20 According to the first aspect the present invention provides a tubular fabric which is particularly useful for receiving an underwire, the fabric comprising a support yarn and a fusible yarn wherein the yarns are formed into a tubular fabric arranging the fusible yarn within the fabric tube so that it is capable of forming a barrier to penetration by a bra wire characterised in that the fabric
25 does not include an elastomeric yarn.

By "fusible yarn" we include the meaning that the yarn can be melted at a predetermined temperature and cooled to adhere to the support yarn. Advantageously, the fusible yarn melts at less than 100°C, especially 90°C

or less, and can be cooled to produce a material having a higher melting point than the predetermined temperature, and preferably more than 100°C.

5 The most preferred fusible yarn for use in the invention is a polyamide yarn, especially that sold by EMS-CHEMIE AG of CH-7013 Domat/EMS, Switzerland under the name Grilon®.

Advantageously, the fusible yarn is in the form of a multifilament, preferably comprising 14 filaments.

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Whilst fusible yarn in the form of monofilaments, such as those produced by Luxilon Industries in Belgium (under the trade name "Luxilon"), or Toray Industries in Japan, could be used in the present invention, a multifilament yarn is preferred because on melting it spreads more easily over the fabric.

15 In contrast, the melting of a monofilament produces a less even spread which may be less comfortable to a wearer of a finished garment incorporating the tubular fabric of the invention.

20 Preferably, the fusible yarn is treated by heating whereby it melts and spreads over the interior surface of the tubular fabric. On cooling, the fusible yarn adheres to the other yarns of the fabric to produce a tubular fabric having a durable inner lining of the melted fusible yarn.

25 Preferably, when the fusible yarn is a polyamide the treatment to melt the fusible yarn comprises a conventional polyamide fabric dyeing process.

The temperature involved in the dyeing process exceeds the melting point of the fusible polyamide yarn. Conveniently, the fusible polyamide yarn is Grilon® having a melting point of 85°C. Typical polyamide dyeing

processes reach temperatures of around 100°C.

5 A particular preferred feature of Grilon® is that on cooling it retains a melting point "memory" for the temperature reached during the dyeing process i.e. after the dyeing process its melting point changes from 85°C to 100°C or more. It will be appreciated that this feature confers the important advantage that the tubular fabric product will not deteriorate on washing by a user in a washing machine because the "new" melting point of the melted fusible yarn will not be reached during normal washing.

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A skilled person will understand that a fusible yarn of the invention is intended to include any yarn which can melt at a predetermined temperature, preferably 70-90°C, more preferably 75-90°C, and adhere to other yarns of the fabric to form a penetration barrier. On cooling, the melted fusible yarn
15 preferably produces a coating, which has a melting temperature in excess of the predetermined temperature and preferably in excess of 100°C.

Preferably, the support yarn is a polyamide, especially a textured polyamide.

20 The support yarn is preferably composed of multifilaments. Preferred support yarns include Nylon 6 or Nylon 66 sold by Du Pont, which comprises a 24 filament, textured polyamide yarn.

It is preferred that the fusible yarn and the support yarn are composed of the same material, advantageously a polyamide, so that they can be adhered to
25 one another easily and so that their respective dyeing properties will be the same. A uniformity of dyeing throughout the fabric of the invention is an important commercial and aesthetic consideration.

Fabrics of the first aspect of the invention do not include an elastomeric yarn.

By "does not include an elastomeric yarn" it is meant that substantially no elastomeric yarn is present in the fabric. Typically the amount of elastomeric yarn present in the fabric of the invention will be less than 0.5%, preferably less than 0.25%, more preferably less than 0.1%, even more preferably less than 0.05%, yet more preferably less than 0.01%, most preferably 0% by weight. Put another way, in the most preferred aspect the fabric of the invention does not have any elastomeric yarn. The term "elastomeric yarn" has a meaning well known in the art and is typically an elastane, e.g. Lycra®, such as product code 2581 distributed by Wykes of Leicester, a particularly preferred Lycra® of the prior art patent GB 2,309,038.

For the purposes of this invention, a yarn will not be considered an elastomeric yarn if it performs as a support yarn and/or a fusible yarn as described above, irrespective of whether the yarn also has elastomeric properties. However, for the yarn to be considered as performing the role of a support and/or fusible yarn, it must comprise by weight at least 10%, preferably 25%, more preferably at least 50%, even more preferably at least 75%, yet more preferably at least 90%, most preferably at least 95% of the total weight of support and/or fusible yarn present in the fabric. Suitable yarns for this purpose include Grilon® covered Lycra®.

The term "underwire" is intended to include any substantially rigid structural member and it need not be made from a metal. For example, a structural member formed from a substantially rigid plastic or from bone may be preferred in certain garments incorporating the tubular fabric of the invention. Such structural members are intended to fall within the scope of the term "underwire" as used herein.

In a second aspect the invention provides a method for making a tubular

5 fabric which is particularly useful for receiving an underwire, comprising providing a support yarn and a fusible yarn wherein the yarns are formed into a tubular fabric by arranging the fusible yarn within the fabric tube so that it is capable of forming a barrier to penetration by a bra wire; and characterised in that the fabric does not include an elastomeric yarn.

10 Preferably, the yarns are formed into a tubular fabric by a weaving process. Whilst the tubular fabric can also be formed by a knitting process, a weaving process is preferred because, in general, weaving produces a denser fabric than an equivalent knitting process. Also, a knitted fabric is typically less comfortable than a woven fabric due to its more open structure.

15 The fabric tubing is preferably formed by weaving two fabric tapes. The tapes are overlaid and their edges joined by edge threads, rising from the bottom tape to the top tape and *vice versa*.

20 Each tape preferably has two weft threads (one being a fusible yarn and the other a support yarn) inserted by one needle and knitted by a catch thread onto a latch needle.

25 It is possible to make a similar tubular fabric using a single weft needle. However, the production rate would be reduced significantly in comparison to the rate possible with a double weft needle. This is because the single needle would require approximately twice the number of picks to produce a fabric having the same strength as that produced by a double needle.

The weaving operation can be performed using a conventional narrow fabric loom. A preferred loom is produced by Jakob Müller AG, of Frick CH-5070 Frick, Switzerland and is known as Model Müller NF 6/27, and is fitted with

a Müller NF system 3 catch thread attachment.

Preferably, threads are woven more loosely on one side (bottom) and the edges of the other side (top) to produce "soft" surfaces for increased comfort
5 to a subsequent wearer.

Preferably the yarns are textured for improved comfort and low shrinkage properties. Advantageously, the yarns are composed of multifilaments.

10 A particularly preferred polyamide yarn is 2 fold 78 dtex textured Nylon 6 or Nylon 66 comprising 20/23 air mingled filaments. These yarns are available from Du Pont.

Preferably, the fusible yarn is 1 fold 75 dtex 14 filament Grilon® K-85,
15 available from EMS, Switzerland.

Preferably the fabric further comprises a catch thread which serves to make a smaller softer knitted edge. Conveniently, the catch thread comprises 1 fold 44 dtex air mingled 13 filament or a 78 dtex 23 filament 1 fold textured
20 Nylon 6 or Nylon 66 (Du Pont).

A skilled person will appreciate that the term decitex (dtex) refers to the thickness of the yarn. Yarns having a lower dtex than the preferred dtex mentioned above would produce a thinner fabric, which may be less
25 comfortable to wear. Yarns with a higher dtex would produce a thicker fabric, which may be less flexible.

In the finished fabric weight the percentages of the different yarns are preferably in the ranges:-

- (i) fusible yarn 5 – 12 %, especially approximately 8%;
- (ii) catch thread less than 1%; and
- (iii) support yarn - balance to give 100%

- 5 If monofilament yarn is used for the fusible yarn, more yarn may be required to achieve satisfactory spreading, and the preferred range is from 5-20%, especially approximately 10%.

10 Preferably, the yarns are preshrunk using conventional heat treatments/washing. This improves the dimensional stability of the final fabric product.

15 Preferably, the methods of the invention comprise a further step of treating the tubular fabric by heating to melt the fusible yarn so that it spreads over the tubular fabric and is capable of forming a barrier to penetration by a bra wire. On cooling, the melted yarn adheres to the other yarns of the fabric to form a durable inner tube lining.

20 Advantageously, when the fusible and support yarns are polyamide, the treatment comprises a conventional polyamide fabric dyeing process, which involves temperatures in excess of the melting point of the fusible yarn.

The preferred fusible polyamide yarn is 1 fold 75 dtex 14 filament Grilon® yarn, which has a predetermined melting point of approximately 85°C.

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Dyeing can be achieved using a continuous pad/steam process, or by a vat (exhaust dyeing) process. In both methods the process is preferably controlled so that the temperature does not fall below a predetermined temperature which is in excess of the melting point of the fusible yarn. The

dyeing temperature is typically 100°C or more.

After dyeing, the dyed fabric tubing is dried and cooled.

5 Conveniently, the fabric can be further treated with a normal dyed fabric finishing step such as acid treatment (using citric acid) to reduce the pH of the finished fabric to less than 4 and thereby protect the fabric from phenolic yellowing which can arise if the fabric is exposed to nitrogen oxide fumes.

10 The fabric tubing produced in accordance with the invention has a durable inner lining of fusible yarn, which is extremely resistant to penetration by underwires.

15 In a preferred embodiment a fabric of the present invention has substantially no stretch characteristics in the width direction. By "substantially no stretch characteristics in the width direction" is included the meaning that the fabric typically stretches by not more than 5%, usually by not more than 3%, more preferably by not more than 2%, even more preferably by not more than 1%, yet more preferably by not more than 0.5%, most preferably the fabric will
20 have substantially no stretch at all in the width direction.

According to a third embodiment of the invention there is provided a method of making a tubular fabric comprising providing a support yarn and an elastomeric yarn and a fusible yarn, the yarns being arranged into a tubular
25 fabric or a fabric that is formed into a tubular fabric, whereby the fusible yarn is arranged within the fabric so that it is capable of forming a barrier to penetration of the tubular fabric by a bra wire; the method comprising treating the fabric so that the yarn strands substantially across the width of the fabric are forced closer together to impart stretch into the fabric in the

length direction.

The composition and production of fabric according to the third embodiment of the invention is described in GB 2,309,038 B to Price Shephed Ltd.

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Stretch characteristics may be imparted in any of the fabrics of the invention by treating the fabric in such a manner that the yarn strands substantially across the width of the fabric are forced closer together thus imparting stretch into the fabric in the length direction. A preferred treatment for imparting

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stretch involves the application of heat and pressure to the fabric. This process is termed compressive shrinkage and is described in EP 0,705,356 and WO 01/11131. Compressive shrinkage can be achieved by use of a machine which comprises means for applying heat and pressure to a woven fabric, and transport means for effecting relative movement between the heat and pressure application means and the fabric whereby passage of the fabric through the apparatus results in the yarn strands substantially across the width of the fabric being forced closer together. Typically this imparts a semi-permanent stretch into the fabric.

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Preferably the stretch is imparted in the length direction. More preferably, substantially no stretch is imparted in the width direction. Put another way, more preferably the stretch of the fabric in the width direction is substantially unchanged by the compressive shrinkage process.

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One passage through the machine will usually be sufficient to impart stretch into the fabric in the length direction, although 2, 3, 4, 5 or more passes may be used.

At the temperature typically used in compressive shrinkage, thermoplastic

yarns within the fabric are heat set so that the extra elasticity imparted to it by the compressive shrinking process is rendered "permanent". Such temperatures typically need to be hot enough to melt the fusible yarn (e.g. Grilon®) but not hot enough to melt nylon. Typically synthetic materials
5 need relatively high temperatures, e.g. about 80-200°, typically about 85-200°, usually about 180°C, to cause compressive shrinkage. Thus, whilst the sleeve used in a compression machine may be constructed with any suitable substance, typically rubber, it is preferred to use a sleeve compound such as EPDM which is less likely to become degraded and hard at these
10 temperatures.

EP 0,705,356 describes a method of importing a stretch into a fabric which is made permanent by simultaneous bonding of the fabric to a synthetic interlining fabric, and is useful for producing a waistband interlining. WO
15 01/11131 describes a method of producing a two-way stretchable fabric by compressive shrinkage, which is useful for producing lining fabrics, particularly for lining garments which themselves have stretch characteristics, e.g. produced with Lycra® or equivalent yarns, such as skirts, jacquard and other plain or printed ribboning, tape or labelling, and can
20 utilise woven fabrics, synthetic non-woven or knitted fabrics.

The process of compressive shrinkage may take place after, before or simultaneously with the process of melting the fusible yarn and/or dyeing the fabric. By "simultaneously" is meant that the temperature of the fabric is not
25 allowed to return to room temperature between melting, dyeing and compressive shrinkage processes. Typically compressive shrinkage is performed after melting and/or dyeing.

Preferred embodiments of the invention will now be described by way of

non-limiting examples, with reference to the following drawings in which:-

Figure 1 is a plan view showing a fabric tape produced according to a preferred weaving method;

5 Figure 2 shows the weft yarns, weft needles and the catch thread latch needle used in a preferred weaving method;

Figure 3 shows the weft paths in the fabric;

Figure 4 is an end view of a fabric tubing according to the invention;

10 Figure 5 shows the drawing in and front reed plan for weaving a closed fabric tubing of the invention;

Figure 6 shows the Heald frame lifting plan for weaving a closed fabric tubing of the invention, wherein X = UP on chain, . = DOWN on chain and C = CENTRE on chain;

15 Figure 7 shows the drawing in and front reed plan for weaving an open fabric tubing of the invention;

Figure 8 shows the Heald frame lifting plan for weaving an open fabric tubing of the invention, wherein X = UP on chain, . = DOWN on chain and C = CENTRE on chain;

20 The preferred fusible polyamide, Grilon® K-85, has a melting point of approximately 85°C and a preferred yarn count dtex of 75. According to the manufacturer's technical data sheet Grilon® K-85 has the following properties:-

	Melting range	78-88°C	(172-190°F)
	Application temperature range	95-120°C	(203-248°F)
	Melt viscosity DIN 53735, 160°C/21.6N		900 Pa.s
5	Yarn count	75 dtex 14 filaments	
	Tenacity	28 cN/tex	
	Elongation at break	40- 70%	
	Twist	300Z T/m	
	Wash resistive	40°C	
10	Dry cleaning resistance	PER-Chloro resistant	

1. Formation of Tubular Fabric

As shown in Figure 1, a preferred fabric tubing 1 of the invention comprises textured polyamide 2 and Grilon® 3 weft threads Wf and polyamide warp threads 6 woven into two tapes which are overlaid and their edges joined by edge threads 4, rising from the bottom tape to the top tape and *vice versa*, to form a tube 5.

Each tape has its two weft threads Wf inserted by one needle N and knitted by a catch thread 7 onto a latch needle 8. Threads are preferably woven more loosely onto one side (bottom) B and the edges of the other side (top) T to give the fabric tube a soft feel to a wearer, as shown in Figure 4.

The tubular fabric is preferably produced using a Müller model NF 6/27 Narrow Fabric Loom fitted with a catch thread attachment (Müller NF System 3).

The loom includes twelve Heald frames. To produce each tape of fabric 2 weft needles, a catch thread attachment, 4 weft thread feeds and 4 weft thread

stop motions (designed to stop the machine should the weft thread break) are employed.

As shown in Figure 2 a double weft needle is used, with each needle B
5 carrying two weft threads 2, 3.

The loom settings are within the general knowledge of skilled person and are as set out in the relevant manufacturer's operation manual.

10 Table 1 -

WARPS	<u>Ends</u>	YARN fold/dtex/ No.filament	COLOUR
Face	44	2/78/20 Crimp Nylon	SMATT
Body	94	2/78/20 Crimp Nylon	SMATT
Edge	32	2/78/20 Crimp Nylon	SMATT
Binder Edge	16	2/78/20 Crimp Nylon	SMATT
Catch thread	1	1/78/20 Crimp Nylon	SMATT
Gut	28	2/78/20 Crimp Nylon	SMATT
Weft	2	2/110/34 Crimp Nylon	SMATT
Weft	2	1/75/14 Grilon® K85	BRT

Reed Per cm	10/8	Per 1" 26/7	
Picks Per cm	13 to 19.5	Per 1" 31-49	
Elongation	15%		
Loom Width	10.5 mm		
Finished Width	10 mm		
m/c Elongation	0%		

Figures 5 and 6 show a drawing in and reed plan and the Heald frame lifting plan to be followed to produce a preferred tubular fabric from the materials
5 given in Table 1, by a weaving process according to the invention.

Table 2 -

WARPS	Ends	YARN fold/dtex/ No.filament	COLOUR
Face	58	2/78/24 Crimp Nylon	SMATT
Body	84	2/78/24 Crimp Nylon	SMATT
Edge	12	2/78/24 Crimp Nylon	SMATT
Gu	32	2/78/24 Crimp Nylon	SMATT
Weft	1	2/110/34 Crimp Nylon	SMATT
Weft	1	1/75/14 Grilon® K85	BRT

Reed Per cm	10/8	Per 1" 22/18	
Picks Per cm	13 to 19.5	Per 1" 34-48	
Elongation	15%		
Loom Width	20.5 mm		
Finished Width	19 mm		
m/c Elongation	0%		

Figures 7 and 8 show a drawing in and reed plan and the Heald frame lifting

plan to be followed to produce a preferred tubular fabric from the materials given in Table 2, by a weaving process according to the invention.

As mentioned previously, the tubular fabric could be produced by a knitting
5 process employing a known fine gauge multi-bar warp or crochet knitting machine.

The preferred method of the invention produces a tubular fabric comprising a polyamide yarn and a fusible polyamide yarn, preferably Grilon® K-85,
10 capable of forming a penetration barrier within the fabric tube. Whilst such a product may be a valuable commercial product in itself, it is preferably subjected to a further heat treatment step to provide a durable lining of fused polyamide on the interior surface of the fabric tubing. Preferably it is also subjected to heat and pressure to impart stretch into the fabric in the length
15 direction.

2. Heat Treatment to Form Durable Tube Lining

In the preferred method the heat treatment step is carried out by a
20 conventional polyamide dyeing process. The vat dyeing process is preferred when the fabric is to be dyed with dark colours such as red, black or blue, whereas the continuous dyeing process is preferred for whites, creams and pastel colours.

25 2. (i) A suitable continuous pad-steam dyeing process of the invention can be carried out with a conventional dyeing machine such as a MAGEBA® Pad Steamer range produced by MAGEBA Textile machines GMBH & Co.

Preferably the conventional device is modified by the addition of a temperature sensing means which monitors the temperature within the dyeing machine. If the temperature falls below a predetermined level e.g. 90°C (in excess of the melting point of the fusible Grilon® yarn, an indicator such as a flashing light or buzzer is activated to warn an operator so that appropriate action can be taken to increase the temperature, as required.

Undyed tubular fabric of the invention is fed, at a rate of approximately 15 metres per minute, into the dye padding unit of the dyeing machine, which utilises a conventional polyamide dye (e.g. available from Hoechst, Ciba-Geigy and Sandoz). The fabric then passes into the atmospheric steamer unit where the fusible Grilon® yarn melts. The fabric is then passed into excess dye wash off baths, size tanks and into drying cylinders (e.g. a drying unit sold by Mageba).

Throughout the process the fabric is maintained under a fixed tension by means of appropriately positioned automatic dancer arms.

The fabric residence time in the steamer unit is 2-3 minutes, preferably 2.75 minutes at a temperature of from 100-105°C. The tubular fabric is dried uniformly whilst controlling the tension of the fabric so that the dimensional stability of the fabric is optimised.

2. (ii) In the vat dyeing process a known Pegg Pulsator can be used. This machine comprises a stainless steel tank in which a dyeing solution can be heated and stirred.

Fabric to be dyed is assembled into 50 metre hanks tied loosely with string bands. The hanks are put into a dyeing solution and heated until the solution

boils (which melts the Grilon® K-85 yarn). Boiling is preferably continued for at least approximately 45 minutes. The dyed fabric hanks are then removed from the tank, rinsed and dried.

- 5 A temperature control is used to warn the operator if the temperature falls below 90°C during the boiling step.

The tubular fabric of the invention is particularly suitable for receiving underwires and is useful in the manufacture of a range of underwired
10 garments including bras, basques and swimming costumes. The tubular fabric of the invention can be incorporated into a garment before or after the underwire is located.

3. Compressive Shrinkage

- 15 Stretch in the length direction may be imparted to open (i.e. non-tubular) or closed (i.e. tubular) tubular fabric of the invention by compressive shrinkage. The open or closed tubular fabric is fed, under heated conditions as described above, into the nip between the roller and the sleeve of an apparatus as described in WO 01/11131. The positioning of the roller causes
20 the path of the open or closed tubular fabric to change from convex to concave, thus compressing the fabric. The fabric is then allowed to fall away and shrinkage is retained. Grounded anti-static bars may be positioned to remove static from the system allowing fabric to fall away from the roller without the stretch effect being reduced or destroyed by static electricity.

- 25 Closed fabric according to the invention (as defined by Figures 5 and 7) produced according to the above examples has a compression of from 5 to 10 % and a stability of -3.0% or less.

The compression of the fabric refers to the reduction in length of the fabric when subjected to compressive shrinkage. The compression value of 5 to 10% means that for every metre of fabric treated one will obtain 90 to 95 cm of compressed fabric.

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The stability value refers to the amount of shrinkage of the fabric when subjected to a normal washing process following compression. A stability value of -3.0% means that upon washing one metre of fabric shrinks to 97 cm.

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The advantage of imparting stretch to the fabric in the length direction is that the stretch allows the fabric to lie flat without puckering when it is machined into garments, for example, when it is curved to receive the bra wire. By imparting stretch into the fabric by mechanical means the need to incorporate an elastomeric yarn such as Lycra® is obviated. This leads to considerable cost savings as the elastomeric yarn is relatively expensive compared to the other yarns of the fabric (other than the fusible yarn). Of course, the incorporation of some elastomeric yarn may still be desirable and such an embodiment falls within the third aspect of the invention.

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4. Tubular fabric production from a flat fabric

A further preferred embodiment of the invention relates to the production of the tubular fabric of the invention from a flat strip of fabric.

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The flat fabric can be formed into a tubular fabric by a variety of methods. For example, the OB1 AT116 system produced by Sew Systems Ltd., S.U.D. Building, 22a Griffin Road, Clevedon, N Somerset, BS21 6HH, England provides a convenient automated method whereby flat fabric is

passed through a folder system which takes the single flat strip and forms it into a tubular form which is sewn into the garment.

As the flat fabric is sewn into the garment, a bra wire is inserted as the
5 fabric is formed into the tubular form.

The flat fabric has the same composition and general method of manufacture as the fabric described in the other embodiments.

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